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BUREAU OF MINES
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INFORMATION CIRCULAR

MINING AND MILLING METHODS AND COSTS AT THE LITTLE PITTSBURG LEAD-ZINC MINE SHOSHONE COUNTY, IDAHO

BY

ROBERT J. HUNDHAUSEN

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

MINING AND MILLING METHODS AND COSTS AT THE LITTLE PITTSBURG LEAD-ZINC MINE, SHOSHONE COUNTY, IDAHO[1/]

By Robert J. Hundhausen[2/]

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INTRODUCTIONS

This information circular is one of a series of Bureau of Mines reports dealing with mining and milling methods and costs. It describes the operations at the Little Pittsburg mine in the Pine Creek area of the Coeur d'Alen mining region near Kellogg, Idaho. The mine and mill have been operated successfully from 1942 to the present.

ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to the Denver Development Co., a four-man partnership now operating the mine under lease, for permission to obtain and publish its cost data. Particularly valuable were the assistance and cooperation offered by Claude E. Nugent, secretary-treasurer of the company. Inar Norgaard, mine superintendent; L. H. Wenerstrom, mill superintendent; Dunham Bell, purchasing agent; K. Preston, engineer; and D. Orcutt, accountant, also were helpful.

LOCATION

The Little Pittsburg mine is in the Yreka mining district (Pine Creek area) of the Coeur d'Alene mining region, Shoshone County, Idaho (fig. 1). The property is only 5 miles in an air line southwest of Kellogg, Idaho, wher a lead smelter and a zinc refinery are situated. The distance by road is 12 miles. The mine may be reached from Kellogg by traveling west on U. S. Highway 10 a distance of 5 miles, thence south over the surfaced Pine Creek road to the forks of Pine Creek, a distance of 4-1/2 miles, thence southeast up th east fork of Pine Creek a distance of 1-1/2 miles, to the confluence of Denve Creek and East Pine Creek. From this junction, a mile of branch road up Denver Creek leads to the mine. This last mile of road is steep, rough, crooked, and narrow but is used for heavy hauling throughout most of the yea

HISTORY

The Little Pittsburg claim was located in 1889 by George Augustus Smith a local prospector. Four other adjoining claims were located by him at inte vals from 1900 to 1916. This group of five claims, now comprising the Littl Pittsburg property, was patented May 14, 1924. In 1915 four claims of the property were leased to the Colonial Mining & Milling Co. No production was made, but in 1915 a 150-ton gravity mill was built. The company became defu

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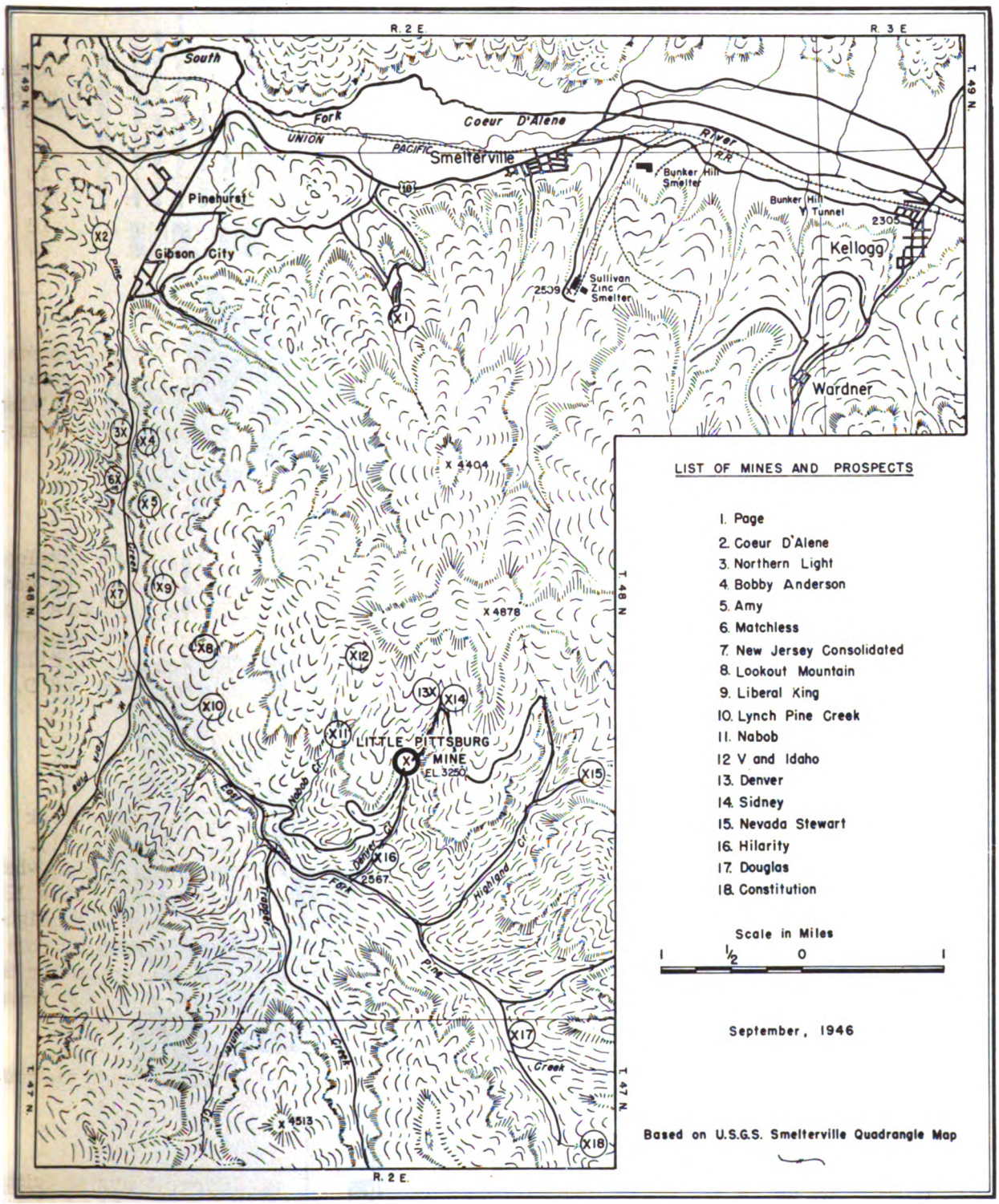

FIG. 1.-LOCATION MAP, LITTLE PITTSBURG MINE, SHOSHONE COUNTY, IDAHO.

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shortly thereafter. In 1927 the property was leased to Walter E. Ingersoll and associates, but the ensuing operations were short-lived and unproductive. In 1929, the Pine Creek Lead Zinc Mining Co., 419 First Avenue South, Seattle, Wash., was formed to take a lease and option on the property. This company erected and operated a 75-ton flotation mill; but, because of the narrowness of the ore body and unfavorable metal prices, the operation was unprofitable. This company, however, retains ownership of the property now. In 1941 about 4,000 tons of ore were produced under another lease agreement, but this operation also was uneconomical.

The Denver Development Co., a four-man partnership, acquired a lease on the property and began operations in March 1942. The mine had been producing a little more than a year when, on July 14, 1943, a ravaging fire, intensified by the explosion of 5 tons of dynamite, destroyed the mill, shops, housing, and much of the mine machinery and equipment. Although handicapped by many difficulties imposed by wartime priorties and shortages, reconstruction was soon started and rapidly completed. The mine began shipping ore to a custom mill in September 1943. By December 1943 the company's reconstructed mill was again in operation. Successful mining and milling have continued ever since. The company's success has been due to competent engineering and management, and to improved metal prices.

The production of the Little Pittsburg mine is shown in the following table.2/

TABLE 1. - Production of the Little Pittsburg mine, 1941-45

Period	Tons milled	Concentrates produced, tons		Recovered metals			
				Pounds		Ounces	
		Lead	Zinc	Lead	Zinc	Silver	Gold
1941.....	4,000	85	493	147,885	532,440	5,000(a)	(?)
1942-45...	107,665	2,990	13,204	5,708,115	13,943,303	133,785	64.24
Totals....	111,665	3,075	13,697	5,856,000	14,475,743	138,785	64.24

(a) Estimated.

Prior to 1941 the production is not known. A graphical representation of the stoping progress made before and since 1942 is shown in figure 2 on the longitudinal projection.

PHYSICAL FEATURES AND CLIMATE

The Pine Creek topography resembles that of most of the Coeur d'Alene region. The drainage pattern of the streams in the lower valleys is moderately trellis-shaped, characteristic of, and consequent upon, folded and inclined rocks underlying the area.

Early maturity seems to be attained in the present cycle of stream erosion. The mountains are steeply sloped; dissection is nearly at a maximum.

2/ Herdlick, J. A., Exploration of the Little Pittsburg Mine, Shoshone County: Bureau of Mines Rept. of Investigations 3999, 1947, 8 pp.

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More or less parallel, steep ridges and valleys alternate with each other, both on a grand and small scale. The master subsequent stream of the area, Pine Creek, is progressively adjusting its drainage system to the weaker formations. For some distance in the Pine Creek area it has eroded an anticlina valley and thus exposes the older rocks of the region. In areas of weaker fo mations its valley bottom is broad and flat. Near its junction with the Coeu d'Alene River, the Pine Creek Valley bottom is nearly a mile wide.

Most of the mines in the Pine Creek area are in the narrow V-shaped valleys of the steep, short, obsequent streams tributary to the East Fork of Pin Creek. These valleys have but little room for mine and mill plants or for tailings disposal. Part of the tailings are impounded in the broader valley of East Pine Creek. The remainder flow several miles downstream to a point where they are impounded by a cooperatively owned suction dredge working in the Coeur d'Alene River.

The Little Pittsburg mine is on Denver Creek, at an altitude of 3,250 feet. It is about a mile above the confluence of Denver Creek with East Pine Creek. Denver Creek is a little over 2 miles long. It heads on a ridge abou 5,000 feet in altitude and empties into Pine Creek at an elevation of 2,600 feet above sea level. It has a small drainage area, a steep gradient, and, during the dry season, an intermittent flow. From June to December, the flow of water from Denver Creek is not sufficient to supply the mill. During this period, most of the water for milling is pumped from Trapper Creek (fig. 1). The pumping system used will be described later in this report.

The climate in the area is not severe; weather below zero seldom lasts more than a few days. During the 4 months of an average winter, snow is seld more than 1 foot deep on the lower slopes, but on the higher ridges 3 to 4 fe of snow is common. The summers are dry and clear, with warm days and cool nights. The Little Pittsburg mine is operated throughout the year. Transpor tation of men and supplies is not seriously affected by weather conditions. All access roads are kept open and maintained throughout the year.

GEOLOGY

The geology of the Coeur d'Alene region has been described by Ransome an Calkins[4] and by Umpleby and Jones.[5] The Pine Creek area has been described by Jones[6] and more recently in detail by Forrester and Nelson.[7]

A single formation of the Belt series, the Prichard, of Algonkian age, underlies most of the Pine Creek area. The Prichard is composed chiefly of distinct and regular bandings of gray and black argillite; locally it is term slate. The Prichard is the lowest member of the Belt series and is probably more than 12,000 feet thick.

4/ Ransome, F. L., and Calkins, F. C., The Geology and Ore Deposits of the Coeur d'Alene district, Idaho: Geol. Survey Prof. Paper 62, 1908, 203 p

5/ Umpleby, J. B., and Jones, E. L., Jr., Geology and Ore Deposits of Shoshone County, Idaho: Geol. Survey Bull. 732, 1923, 156 pp.

6/ Jones, E. L., Jr., A Reconnaissance of the Pine Creek District, Idaho: Contributions to Economic Geology, Geol. Survey Bull. 710, 1919, pp. 1-

7/ Forrester, J. D., and Nelson, Vincent E., Lead and Zinc Deposits of the Pine Creek Area, Coeur d'Alene Mining Region, Shoshone County, Idaho: Geol. Survey Strategic Minerals Investigations, 1944, 27 pp.

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Forrester says:8/

> The rocks of the area (The Prichard formation) have been deformed by close local folding on a small scale, on which has been superposed at least one broad anticlinorial fold. They are further broken into large blocks by normal faults or by faults on which the movement has been essentially horizontal.

The amplitude of the broad anticlinorial fold is of such proportions that the Prichard formation generally has moderate to steep, northeasterly dips throughout the Pine Creek area. Minor anticlinal axes and bedding strikes have principal trends in a NW-SE direction.

Both fissure fillings and replacement-type lead-zinc ore deposits are found in the Pine Creek district. Most of the deposits, however, are metasomatic fissure veins in alinement along master zones of discontinuous faulting, fracturing, and shearing. These zones may be adjacent to, or divergent from, the larger, more continuous, barren faults.

The Little Pittsburg ore shoots are localized along a mineralized fault fissure. The horizontal trace of this fissure curves uniformly from N. 15° to 40° W. on the No. 6 level of the mine. The fissure dips 65° SW., transverse to the dip of the slate bedding. The ore is in replacement lenses, disseminations, stringers, and veins within, or adjacent to, the fault fissure. In most places the fault fissure has well-defined walls enclosing narrow widths of massive sulfides. A persistent seam of gouge a few inches thick is usually present and serves to guide the operators in following the vein. In other places, the ore mineralization may extend outward into the jointing, drag folding, and bedding of the slate. In such cases mining widths are increased to the limit of assay walls. Thus the vein material is found in widths ranging from 0.5 to 30 feet or more; the mining width has averaged about 5 feet.

The position of the ore shoots in plan and section, and the fact that the ore shoots are in the steeper parts of the fissure, suggests normal and horizontal movement along a premineral, sinuous fault surface. Furthermore, the intervening barren parts of the vein between the ore shoots are tightly compressed and sheared. These tight parts of the vein may represent bearing or compressional areas where the fault surfaces opposed each other in their movements. In general, the massive sulfide veins with well-defined walls are found in the open parts of the fissure or where there has been the least resistance and pressure. The greater vein widths are usually associated with cross faults which displace the vein only a few feet.

Three ore shoots have been mined (fig. 2), the first throughout a dip length of 400 feet and a strike length of 200 feet. It is separated from the second ore shoot by 270 feet of sheared, low-grade vein material. The second and principal ore shoot is 520 feet long and has been mined to a depth of 500 feet vertically below the surface. The third ore shoot is being developed. It is about 130 feet long.

8/ Work cited in footnote 7.

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The Little Pittsburg ore is a fine-grained mixture of sphalerite, galena, pyrite, and pyrrhotite in a gangue of unreplaced argillite and quartz. Small quantities of chalcopyrite and gold are present. The ratio of lead to zinc is about 3:7. At current metal prices and costs, the minimum grade and width of ore that can be profitably mined are, roughly, about 2 percent lead and 6 percent zinc over a stoping width of 3.5 to 5 feet.

PHYSICAL CHARACTERISTICS OF ORE AND ROCKS

The hanging wall of the Little Pittsburg vein is not strong. In the wide parts of the vein the walls may be ill-defined and may tend to slough. Shrinkage stoping of these parts of the vein has been found to be impractical. When the vein is narrow and contains considerable quartz, it is sometimes practical to mine short sections of the vein by shrinkage methods. Nevertheless, most parts of the vein require modified square sets or stringer sets.

DEVELOPMENT OPENINGS

The main haulage level at the Little Pittsburg mine is the No. 6 drift adit. All stoping to date has been from above this level. Level intervals are approximately 125 feet apart vertically. Three levels, No. 5, No. 4, and No. 3, are developed above No. 6 level.

An underground, inclined shaft on a 62° dip gives access to the workings below No. 6 level. The No. 7 level is turned from the shaft at an altitude 138 feet lower than the No. 6 level. The No. 7 drift is 750 feet long. It extends 350 feet south and 400 feet north of the shaft.

Stope preparations are now in progress to mine the ore between the No. 7 and No. 6 levels. Two main supply raises are being driven, one at each end of the No. 7 level. These will aid in ventilation and will relieve the shaft of handling much equipment and supplies.

DRIFTING METHODS

Drifts in waste, and crosscuts, are usually untimbered, but drifts in ore are timbered. Most drifts are 6 by 8 feet in cross section. Usually one stope round is blasted from the back directly above the drift before any timbering is done. Drift sets are then installed and chute lips are built at 20-foot intervals. Drifts posts are 8 inches by 8 inches by 8 feet and caps are 10 by 10 inches by a length sufficient to allow room for blocking at both ends. The caps are unframed, but 2- by 8-inch random-length lagging is scabbed on the bottom of the cap to prevent the posts from being squeezed inward.

Three-inch lagging is placed directly over the caps to support the broken ore. Some cribbing may be necessary above the lagging to support hanging-wall slabs. No sills or foot blocks are used for the drift posts. The width between the posts usually is about 6 feet; it may be more than 6 feet where the vein is exceptionally wide. The posts are on 5-foot centers along the drift. Girts are 4 feet 4 inches long by 3 by 6 inches. They are spiked to the posts just beneath the caps. Timbering is done by a special crew on day's pay or company account.

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All mucking in drifts is done with a mucking machine. A Gardner Denver Model No. GD-9 is used. Approximately 3 hours is required to muck out a round, lay track, and set up for the next round.

All drifts are driven on contract. The labor rate averages about $7.00 per foot of drift. No one type of round is used exclusively. The miners are free to use their own judgment in drilling, as it is to their advantage to break clean rounds for the least drilling. Burnt cuts, pyramid cuts, and V-type cut rounds are all used.

The cut holes are 6-1/2 to 7 feet deep. An average round pulls 6 feet. About 26 holes are drilled per round. About 300 sticks of powder or 12 sticks to the hole are used in blasting. Several different brands of powder have been used, depending on the supply available. Probably 45-percent ammonia gelatin dynamite is used most of the time. The ammonia gelatin dynamite is preferred because it produces a smaller volume of poisonous gases than ammonium nitrate dynamite of the same strength. Furthermore, the miners cannot use as much of the ammonia gelatin dynamite as they can use of the other dynamites, in a hole of given size. No. 6 blasting caps and fuses are used for primers for all blasting, except in the shaft. The primers are made by the outside timberman.

Gardner-Denver drifters, Model D-898BH, mounted on pneumatic drifter columns, are used for drilling. The machines accommodate a 30-inch change of steel. Round, lugged drill steel, 1-1/4 inches in diameter, is used. The starter bits are gaged at 2-1/4 inches. Bit gages are reduced by 1/8 inch for each change in steel. Broken steel is rethreaded, shanked, and reused whenever it is possible to do so. All shanks and threads cost 95 cents each.

Timken detachable cross bits (type M) are used for all types of drilling. The motormen deliver the bits into the mine each day. The bit holder is homemade. It is made from a piece (about 15 by 18 inches) of 1/2-inch rubber belting. A short piece of hose is riveted on the long edge to form the handle. The bits are carried on short pieces of threaded drill steels, which pass through the belting and project from it on each side about an inch and a half. The holder accommodates 48 bits arranged in 6 rows of 4 bits each on each side. It will withstand much abuse and is lighter than most bit carriers.

RAISING METHODS

Main supply raises have either four or three compartments. These are termed three-cap raises or two-cap raises, respectively. This denotes the quantity of timber used - in the first case, two complete timbered sets, or three caps, and in the second one complete timbered set, or two caps.

In a four-compartment raise the two outside compartments are used for chutes. They are called joker sets because they are not timbered. In these chutes three sides are rock. The fourth side is formed by the timbered and lagged end of one of the inner compartments.

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The timber in a four-compartment raise consists of six posts, 4 inches b 6 inches by 4 feet 4 inches, and three 10-inch-diameter round caps cut to fit wall conditions. Girts are 3 by 6 inches in cross section and are 4 feet 4 inch long. One of the inner compartments is used as a timber slide for hoisting supplies. It also carries the water and air lines. The other inner compartment is used for the manway. These compartments are laced on the ends with 3-inch by 5-foot lagging to form the fourth side of the two chute compartment

Cleveland, Model SS22, and Gardner Denver, Model R-104, automatic rotating stopers are used for drilling in stopes and raises. These use 1-inch quarter-octagon steel. The stopers will accommodate 18-inch changes in steel lengths. Starter steels are usually 30 to 36 inches in length; seconds, 48 to 54 inches; thirds, 66 to 72 inches; and finishers, 84 to 90 inches. Bit sizes range from 2-1/4 inches for starters downward by 1/8-inch changes in bi gage for each change in steel.

In a 5-foot round in a three-cap raise, an average of 30 holes will be drilled. A V-type of cut is used. The usual powder charge is eight sticks to a hole. Two miners on contract drill and blast one round in a shift. Timbering and miscellaneous work require another shift. The raise advance thus averages about 2-1/2 feet per one-shift day. The raises are generally driven from level to level before stoping is begun. They are about 150 feet long and 80 to 100 feet apart.

The timbering for a two-cap raise consists of four posts, two caps, and two girts. This forms one complete set 4 feet 4 inches in the clear. Untimbered chute compartments are adjacent to each end of the timbered set. The set forms the manway and also carries a small timber slide. It is lagged on each end with 3-inch sawed planks.

The two-cap raises are driven on contract at a labor rate averaging $12.0 per foot. About 18 holes are drilled, with a V-type cut, for a 5-foot round. This round breaks a rock section about 6 by 15 feet. The powder charge is 8 to 10 sticks to a hole. The practice is to break fine. The timber is kept within 2 or 3 feet of the back and is double-lagged before blasting.

SINKING METHODS

An underground, two-compartment shaft has been sunk to a depth of 240 feet below the No. 6 level (fig. 2). The shaft is inclined 62° below the hori zontal. The framed shaft timbers have the following dimensions:

Wall plates.....	8" x 8" x 10'
End plates.....	8" x 8" x 5'4"
Dividers.....	8" x 8" x 4'2"
Posts.....	8" x 8" x 5'2"

The compartments are 4 by 4 feet in the clear. Conventional framing is employed. One set is used for a manway and the other for the skip.

The shaft is lagged on all four sides with a 2-inch lagging 5 feet long. The standard Coeur d'Alene system of cleated lagging is used. The lagging is

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placed between the timber sets in slots formed by cleats nailed to the wall and end plates.

The collar sets were timbered with 10 by 10's rather than 8 by 8's. No bearing sets are used. The timber is untreated fir; the blocks are cedar.

Shaft rounds are drilled with Gardner Denver automatic drifters mounted on air columns. Approximately 30 holes are used with a V-type cut, which throws much of the muck to the manway set. An average of 100 pounds of powder per round is used. This is about 8 sticks to the hole, with 10 sticks in the cuts. All shaft rounds are blasted with electric delay detonators equipped with 12-foot leads connecting in parallel to two bare wires across the bottom of the shaft. The bare wires are wired to a permanent blasting circuit of 220 volts.

Hand mucking is employed. The broken rock is shoveled directly into the skip which is lowered to the bottom of the shaft on extension rails.

The skip compartment has a 36-inch gage, 20-pound rail for the skipway, and a middle rail, 24-inch gage, for lowering other haulage equipment to the No. 7 level below. An open stope above the collar of the shaft was utilized for headroom in dumping the skip. The skip is dumped in a conventional manner. The upper wheels engage a curved rail while the lower wheels are elevated to a higher position on the main incline, thus dumping the load. A steel gate, hinged along the vertex of an inverted V-type splitter, may be swung in such a way as to divert the dumped material either to the waste or ore pocket.

A 5-horsepower motor, operating a Coppus TM-6 "Ventair" fan, constantly exhausts the air from the bottom of the shaft through a 12-inch galvanized vent pipe supported in the manway set. An arrangement will be made on the No. 7 level to draw air out of the headings through the same vent pipe.

The hoist is operated, through a gear-reduction set, by a 52-horsepower Western Electric motor. The drum is 3 feet in diameter and has a 3-foot face. A 3/4-inch 6 by 19 plow-steel cable is used.

STOPING METHODS

Evolution of Stoping Practice

Several stoping methods have been used in mining the Little Pittsburg ore. As the disadvantages of each method became evident through actual practice, that particular method was either modified or discontinued. The outgrowth of this work has led to the general practice of a modified square set or stringer set stoping method.

Before describing this method in detail, a brief résumé of the various methods used in the past will be given to illustrate some of the mining problems. For example: In the modified square-set stoping method originally used at the Little Pittsburg mine, the broken ore was allowed to fall through the timbered slopes directly onto the draw floor above the drift. An attempt was

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made to mine from the No. 5 level to the top of the ore body in a single lift. As stoping progressed upward it was found, through experience, that the practicable maximum height for dropping ore through the stopes was about 150 feet; ore dropped from greater heights would dislodge too much timber and endanger the support. Furthermore, the cost of handling stoping timbers and supplies also increased as stoping progressed upward. To circumvent these difficulties a shrinkage method with a slusher-drift system of ore transfer was adopted in parts of the upper mine workings where the ore and walls appeared to be strong. The normal preparation for the shrinkage method was as follows: A 6- by 8-foot untimbered slusher drift was driven in ore for a length of 200 feet in both directions from the top of an ore-transfer raise. Pillars above the drift were left for level protection, and draw chutes were installed at 20-foot intervals. A stope drift connected the chute raises at the top of the pillars and formed the bottom of the stope. The stopes were mined upward by successive horizontal cuts, using a conventional shrinkage-stoping method. None of the shrinkage stopes were successful because considerable dilution took place when the stopes were pulled. One 200-foot stope had to be timbered to prevent excessive dilution as the muck was drawn. In some cases the level pillars were robbed after the stopes were emptied; in others, the stopes had caved so much that the pillars were lost.

A method of sublevel shrinkage stoping was then tried in one small stope. In this stope the mining was done directly over drift sets; level pillars were not used (fig. 3). After the stope was mined upward a distance of 25 feet by normal shrinkage methods, a sublevel stope drift was timbered, and new chutes were built. The sublevel-drift timbering was identical to that of the main-haulage-drift timbering, except that the posts rested on sill caps hitched in both walls. It was then possible to draw the broken ore from the lower stope and begin another shrinkage stope above the sublevel timbered drift. In this manner, the quantity of broken ore in the stope was reduced to a minimum, and greater flexibility in stoping operations was attainable. The shrinkage stopes were small, the broken ore was quickly removed, and dilution was correspondingly reduced. Nevertheless, the cost savings were not sufficient to compensate for the relatively low selectivity inherent in shrinkage methods. All shrinkage methods have now been abandoned in favor of the modified square-set method described under the following heading.

Square-Set Stoping Method

A modified square-set system of mining is now used throughout the mine. These stopes are started directly over the haulage drifts. The drift sets are lagged with 3-inch lagging, and chutes are installed at three- or four-set intervals. Development raises are driven at each end of the stoping block. The stoping blocks are usually about 90 feet long. The stope sets are identical to those used in the raises. They consist of two posts, 4 inches by 6 inches by 4 feet 4 inches, one round cap, 8 to 10 inches in diameter, and two girts, 3 inches by 6 inches by 4 feet 4 inches. Most of the weight is held by the caps. The small size of the posts makes them inexpensive and easy to handle and transport.

The stopes are mined by successive horizontal cuts (see fig. 4). Room for four sets may be excavated before timber is placed. As a rule, stope

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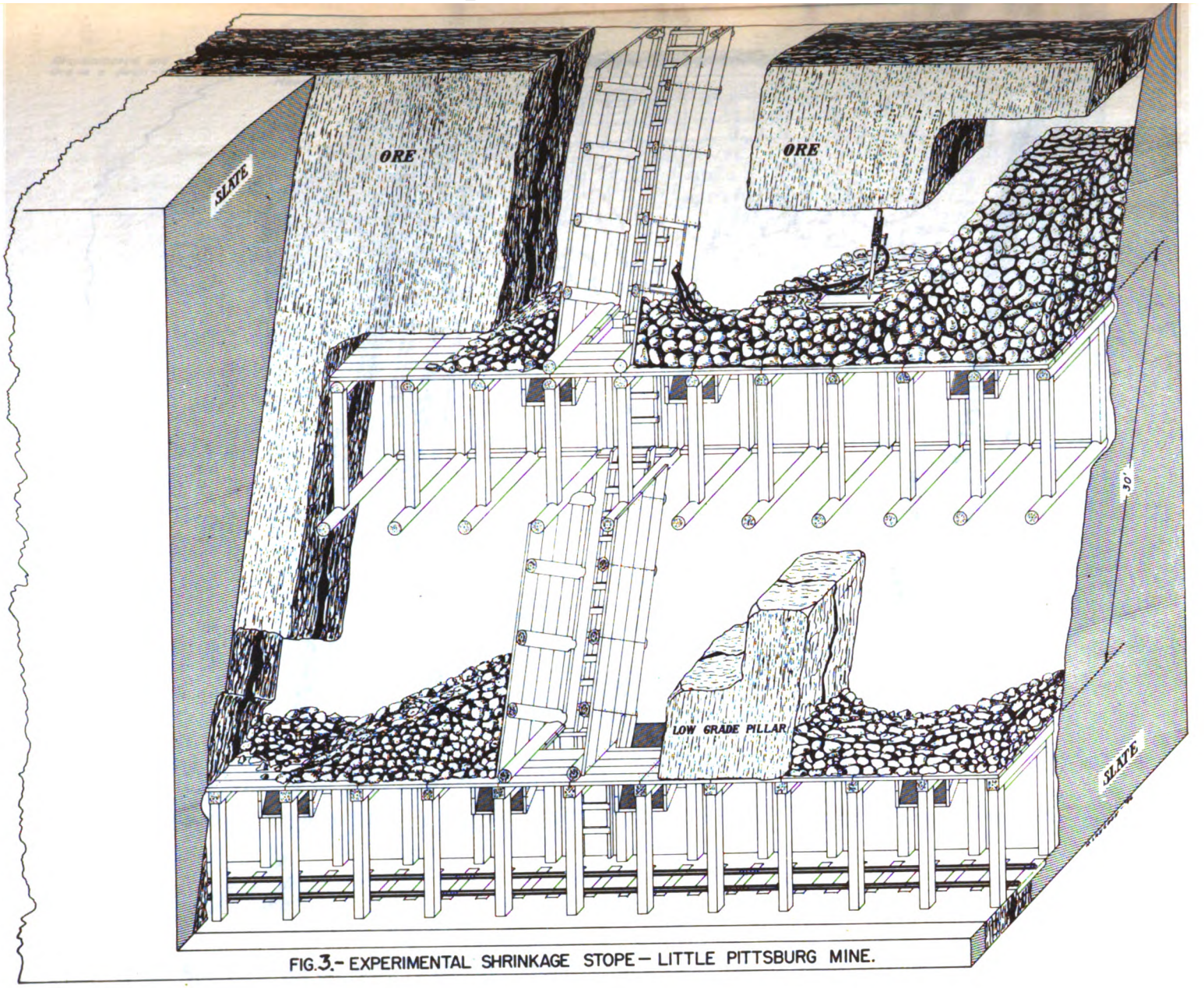

FIG. 3.- EXPERIMENTAL SHRINKAGE STOPE — LITTLE PITTSBURG MINE.

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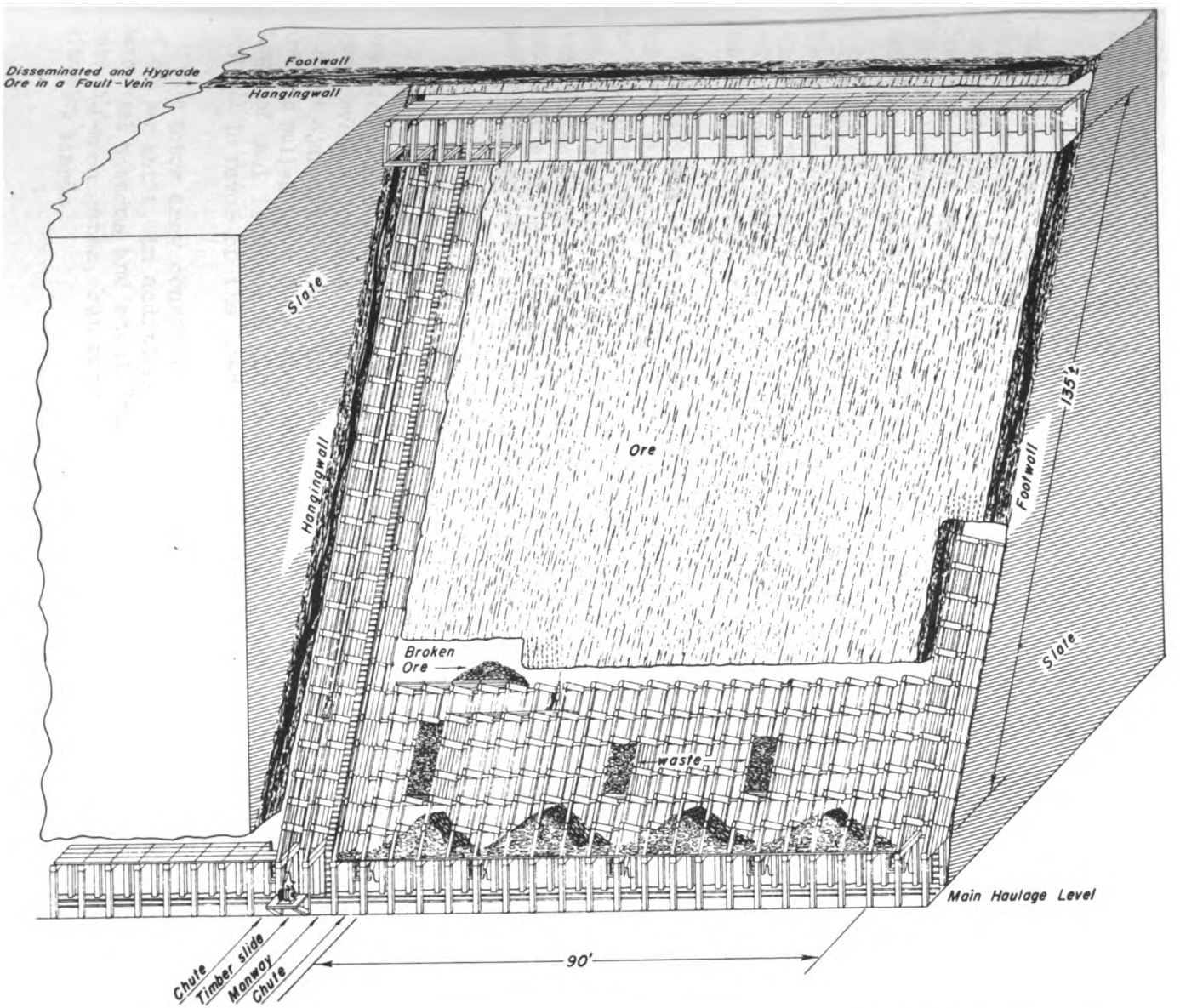

FIG. 4.— TYPICAL STOPING METHOD USED AT THE LITTLE PITTSBURG MINE.

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filling is not done and is not necessary. In one stope in the upper mine workings, however, the vein branched, and both the foot-wall and hanging-wall branches were stoped. The foot-wall stope began to take weight, so it became expedient to fill it. The waste used for filling was obtained from hanging-wall inclined raises and also from an inclined "bean-hole" exploration raise in a more barren part of the vein.

Successive horizontal slices are timbered to within 3 feet of the back and the uppermost sets are floored with double lagging before blasting. An 8-inch ore pass opening is left in the floor. After the ore is blasted onto the lagging the larger pieces of waste, if any, are sorted and stored in waste "corrals" built by lagging off certain sets. The ore is then allowed to drop directly through the timbered stope onto the draw floor. Very little hand mucking is necessary in the stopes.

Timber, powder, bits, and steel are delivered to the miners in the stopes. The caps are cut to measure in the timber yard at the portal of the main haulage adit. The yardman cuts the stulls to measure and marks the length and delivery point (working place) on each piece. Powder is delivered by a powder man who takes orders for and delivers the day's requirements to the miners.

Most of the stoping at the Little Pittsburg is done on a day's pay basis, but a few stopes are mined on contract. The contract stopes are measured twice a month, on the first and sixteenth. The contract price varies in accordance with the width of stope, men involved, and general mining conditions in the stope. About $13.00 per set is paid for the average stope contract. This is on a basis of 25 square feet in a set. Stope drifts generally are paid at the rate of $7.00 per foot.

TRAMMING

All of the ore from the mine is hauled out through the No. 6 level. The track is 24-inch-gage, 16-pound rail with 4-inch by 6-inch by 3-foot ties spaced every 21 inches. The usual ore train consists of nine Coeur d'Alene Hardware Ajax-type cars. The cars have a capacity of 30 cubic feet. The train is pulled by a 2-1/2-ton Mancha Titan B battery locomotive. The average length of haul is about 2,000 feet one way. Track grade is about 0.5 percent downhill in favor of the load.

The motor crew consists of two men. One train crew trams about 75 tons of ore per shift, in addition to its other duties. Chutes at the shaft pockets have steel bottoms and steel "half-moon" gates. Some of the transfer chutes have half-moon gates, but most stope chutes are of ordinary wood construction with stop boards.

SAMPLING

No underground sampling is done at the Little Pittsburg mine. The vein is relatively easy to follow, and the superintendent can tell from experience what ore will meet the required grade. Eight-foot test holes are drilled into the walls at intervals as the drifts are being driven.

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VENTILATION

The mine is favorably situated and developed to obtain a strong natural ventilation throughout most of the workings. In long headings and in shaft-sinking, small blowers aid in removing the gases.

TRANSPORTATION

Transportation of the men from Kellogg and intermediate points to and from the mine each day is furnished by the company. This service costs the company $350.00 per month for 30 men.

MILLING METHODS

The Little Pittsburg mill is situated in the bottom of the steep-sided canyon of Denver Creek, 300 feet from the portal of the No. 6 main haulage level. The mill has a capacity of 150 tons per day. Selective flotation of lead and zinc is accomplished. The flow sheet is shown in figure 5.

The mine-run ore is dumped over a 8-inch grizzly of 20-pound rails into a 75-ton wooden ore bin. The larger pieces of waste retained by the grizzly are sorted out and thrown into a waste chute. This chute, when full, is emptied into a truck. The waste is then trucked to a waste dump, where more space is available.

The ore is taken from the bin through a hand operated chute gate onto a 1-3/4-inch shaking screen manufactured to company specifications. The undersize is conveyed to the cone crusher. The oversize is conveyed to the jaw crusher. Wood and iron are removed by hand from the oversize as it travels to the jaw crusher. The oversize is crushed in a 9- by 15-inch Union Iron Works jaw crusher operated by a 50-horsepower motor. A 35-horsepower motor, no doubt, would be large enough. The dust produced at the jaw crusher is removed through a vent pipe by an exhaust fan rotated by a 10-horsepower motor

The crushed product is conveyed to a 1-inch Allis Chalmers air-flow vibrating screen. The oversize is returned to the cone crusher. The undersize drops directly into a 225-ton, fine-ore bin.

The No. 22 Fahrenwald, 24-inch, swing-head cone crusher receives the undersize from the 1-3/4-inch screen and the oversize from the 1-inch screen. The cone-crusher product is returned to the 1-inch screen.

The coarse crushing plant described above operates only about 30 percent of the time because its capacity is much larger than that of the fine grinding mill. When greater ball-mill capacity is desired, the coarse ore is crushed to pass a 7/8-inch screen rather than a 1-inch screen.

The ore is removed from the fine-ore bin through two chutes in the bottom of the ore bin. These chutes are arranged in tandem. The opening at the top of each chute in the bottom of the bin is 12 by 24 inches. Each of the chutes is built in the shape of an inverted truncated wedge, having an altitude of 16 inches. The bottom opening is 12 by 16 inches. Two Ziegler, reciprocating plate feeders, one under each chute, control the flow of ore. No weigher is

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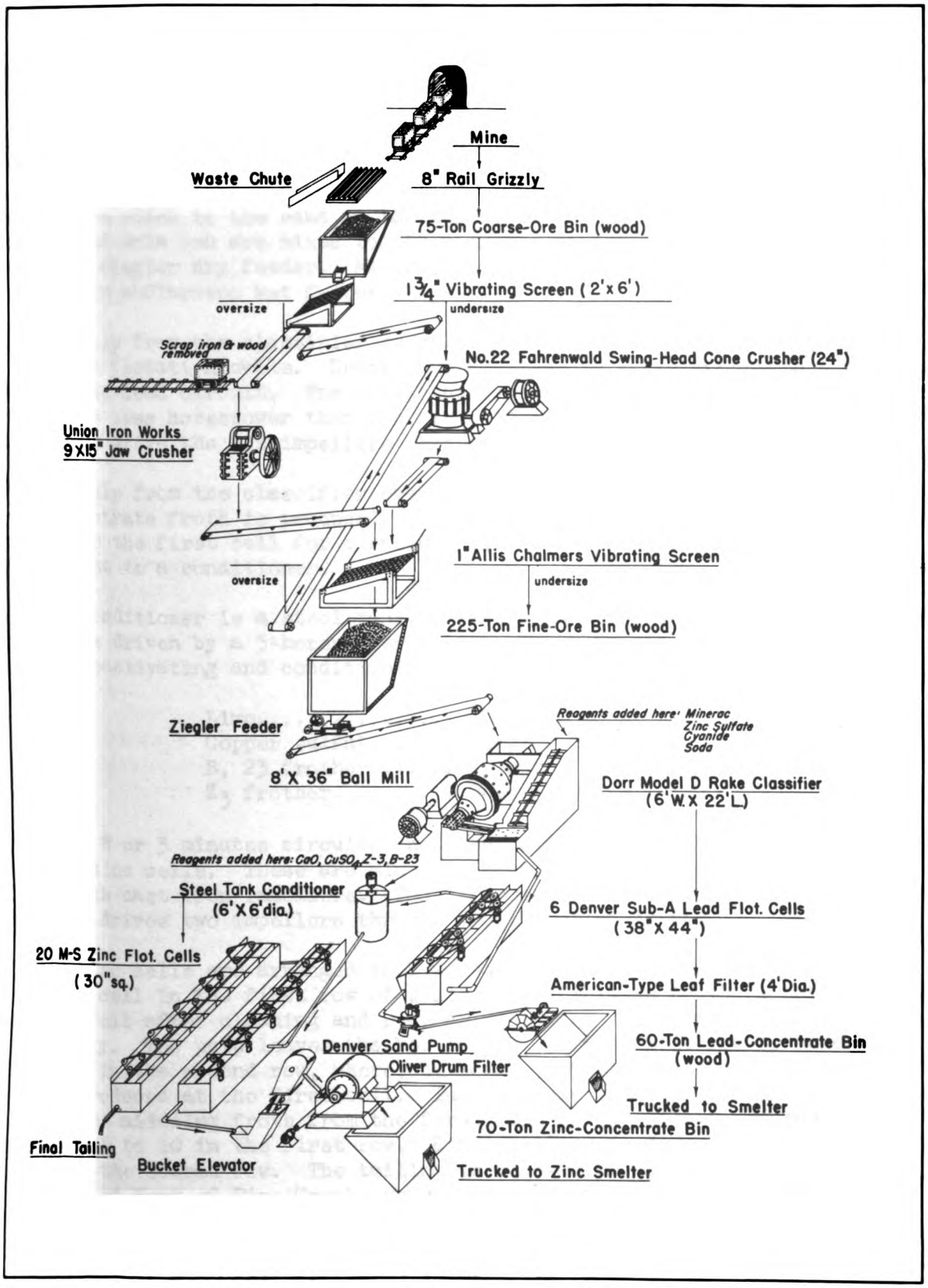

FIG. 5.–FLOW SHEET, LITTLE PITTSBURG MILL.

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used. The fine ore is conveyed to an 8-foot by 36-inch conical ball mill. The mill rotates at 21 r.p.m.; it is driven through a Falk reduction gear set by a 2,200-volt 150-horsepower motor. A small fan cools the ball-mill motor, which is slightly overloaded. Three-inch-diameter, cast-iron balls are used for grinding the ore to 90 percent minus 200-mesh. The ball mill is in closed circuit with a Dorr Model D rake classifier, 6 feet wide by 22 feet long. Reagents are added to the sand at the head of the classifier. Zinc sulfate, cyanide, and soda ash are mixed together in the proper proportions and fed by means of a Ziegler dry feeder. Minerac, a xanthate derivative, is fed to the sand through a Clarkson wet feeder.

The pulp from the classifier overflow goes without further conditioning to six lead flotation cells. Denver Sub A cells, 38 by 44 inches in area, are used for the lead circuit. The cells have rubber impellers; these wear longer and require less horsepower than cast-iron impellers. Two 10-horsepower induction motors drive the six impellers through V-belt drives.

The pulp from the classifier overflow enters the first float cell where a lead concentrate froth is produced. The second cell produces a froth which is returned to the first cell for cleaning. The pulp discharge from the last cell is sent to a conditioner.

The conditioner is a steel tank, 6 feet high and 6 feet in diameter. The impeller is driven by a 5-horsepower motor. The reagents added and feeders used for reactivating and conditioning the zinc are as follows:

Lime.....	Denver feeder
Copper sulfate.....	Ziegler feeder
B, 23 frother.....	Clarkson feeder
Z_3 frother.....	Denver feeder

After 2 or 3 minutes circulation in the conditioner, the pulp is pumped to the 20 zinc cells. These are Minerals Separator-type cells, 30 inches square, with cast-iron impellers. Ten 5-horsepower motors drive the impellers; each motor drives two impellers through V-belt pulley drives.

The zinc cells are arranged in 2 rows of 10 cells each. The pulp enters the fourth cell in the first row of cells. The finished froth is taken from the first cell after cleaning and recleaning in the third and second cells, respectively. The pulp leaves the No. 10 cell in the first row to enter the No. 4 cell in the second row, where, by means of a similar circuit, a middling froth is produced at the first cell. The No. 3 cell in the first row of cells receives the middling froth from the first cell in the second row and also that from cells 4 to 10 in the first row. Final tailing is discharged from the No. 10 cell in the second row. The tailing is allowed to flow down Denver Creek into the East Fork of Pine Creek, where arrangements are made to impound it.

The finished zinc concentrate froth is lifted by means of a bucket elevator to an Oliver drum filter, 8 feet in diameter and 6 feet long. The concentrate is dewatered and dropped into a 70-ton wood concentrate bin.

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The lead concentrate froth is pumped by a Denver vertical sand pump to an American-type, 4-foot-diameter, two-leaf vacuum filter. The concentrate drops from the filter directly into a 60-ton, wood concentrate bin.

One vacuum system serves both filters. A Doak piston-type vacuum pump is used. The filtrate from the zinc filter is returned to the zinc flotation circuit. A Connersville-type blower system, producing 2 pounds air pressure, is used to blow off the filter cake.

The dried concentrates are trucked to either the Bunker Hill lead smelter or the Sullivan Zinc smelter at Kellogg, Idaho (fig. 1). The transportation cost for either concentrate is $1.25 per ton.

Hand samples of the head, concentrates, and tailing are taken every hour every shift. The samples for each shift are composited and assayed. Assays are made at a neighboring property. Consistently uniform results and good recoveries have been obtained throughout the operations.

The water supply for the mill is obtained from several sources. Approximately 125 gallons of water per minute is required for milling 140 tons of ore per day. During the late winter and spring months most of the water is obtained by gravity flow from the mine and from Denver Creek. During the dry months of the year, from June to December, the principal water supply is obtained by pumping from Trapper Creek. An Aldrich 4 by 7 triplex pump, driven by a 2,200 volt, 35-horsepower motor, is used in this system. The pipe-line consists of 4,000 feet of 4-inch Victaulic pipe and 2,500 feet of 6-inch wire-wrapped wooden pipe. This line empties into a 10-foot-diameter, 20-foot-deep, reinforced wood storage tank at the mill. The tank capacity is about 11,750 gallons. The water is elevated through an altitude range of approximately 800 feet. The average cost of power for pumping during 6 months of the dry season is $123.00 per month.

ACCOUNTING PRACTICE

The Little Pittsburg mine and mill supplies are inventoried in complete detail each month. The labor cost is, of course, known definitely for each day and for the month. Power costs are obtained each month from metered power bills. Stope and development progress are measured twice a month. Similarly all information needed to calculate the financial progress of the organization each month is obtained in sufficient detail to give complete working costs.

Figure 6 is a reproduction of all the daily record forms used at the Little Pittsburg mine. Three of these forms are for the purpose of distributing detailed labor, explosive, and timber costs to the respective working places. The daily ore tally is self-explantory. Mill supplies are also detailed each day. By the use of these records it is possible to get reasonably accurate detailed cost figures for all phases of the development, mining and mill work.

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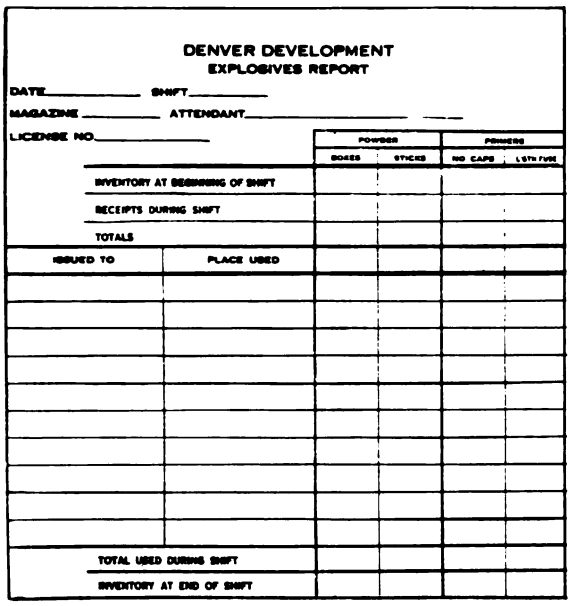
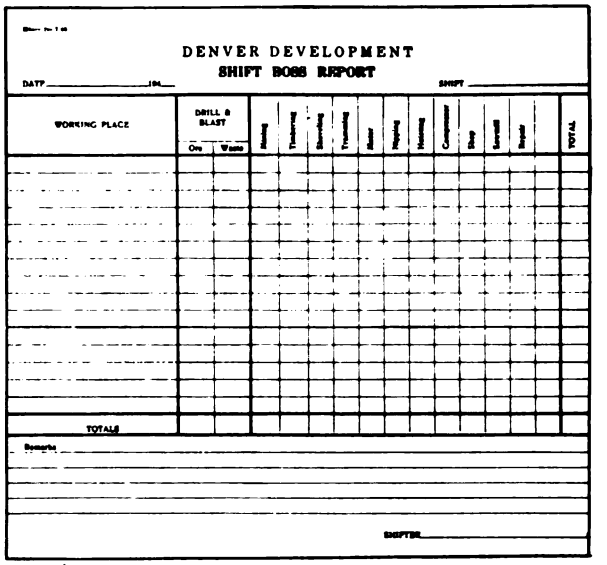


DENVER DEVELOPMENT
EXPLOSIVES REPORT

DATE _____ SHIFT _____
MAGAZINE _____ ATTENDANT _____
LICENSE NO. _____

		POWDER		FUSE	
		BOXES	STICKS	NO. CAPS	LGTH. FUSE
INVENTORY AT BEGINNING OF SHIFT					
RECEIPTS DURING SHIFT					
TOTALS					
ISSUED TO	PLACE USED				
TOTAL USED DURING SHIFT					
INVENTORY AT END OF SHIFT					



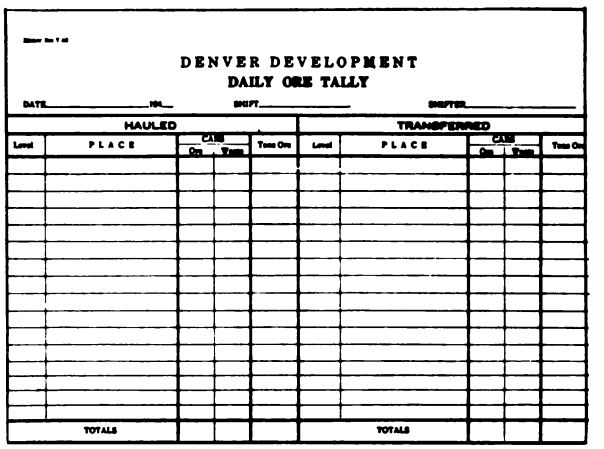
DENVER DEVELOPMENT
SHIFT BOSS REPORT

DATE _____ 19__ SHIFT _____

WORKING PLACE	DRILL & BLAST		Mining	Timbering	Shoveling	Trimming	Rock	Hauling	Hoisting	Compressor	Shop	Lowboy	Repair	TOTAL
	Ore	Waste												
TOTALS														

Remarks _____

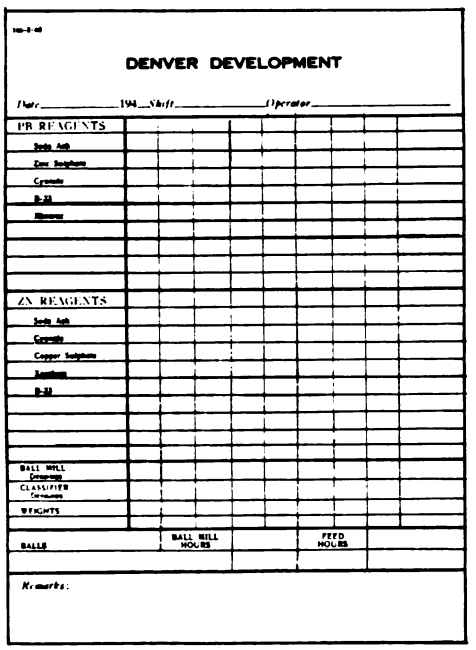
SHIFTER _____



DENVER DEVELOPMENT
DAILY ORE TALLY

DATE _____ 19__ SHIFT _____ SHIFTER _____

HAULED					TRANSFERRED				
Level	PLACE	CARS		Tons Ore	Level	PLACE	CARS		Tons Ore
		Ore	Waste				Ore	Waste	
TOTALS					TOTALS				



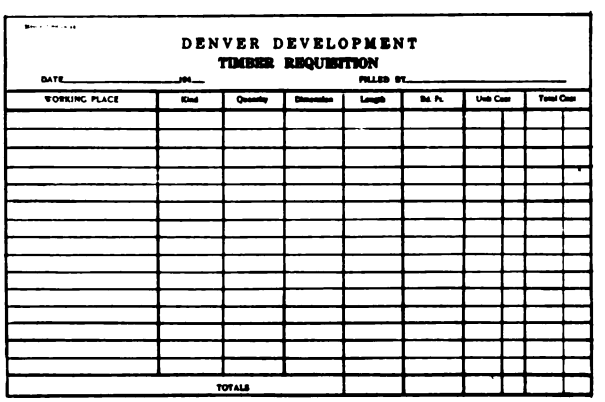
DENVER DEVELOPMENT

Date _____ 19__ Shift _____ Operator _____

PB REAGENTS								
Soda Ash								
Zinc Sulphate								
Cyanide								
B-31								
Minerec								
ZN REAGENTS								
Soda Ash								
Cyanide								
Copper Sulphate								
Xanthate								
B-31								
BALL MILL Comp. Mins								
CLASSIFIER Comp. Mins								
WEIGHTS								

BALLS		BALL MILL HOURS		FEED HOURS	

Remarks:



DENVER DEVELOPMENT
TIMBER REQUISITION

DATE _____ 19__ FILLED BY _____

WORKING PLACE	Kind	Quantity	Dimension	Length	Bd. Ft.	Unit Cost		Total Cost	
TOTALS									

FIG. 6.—DAILY RECORD FORMS USED AT THE LITTLE PITTSBURG MINE.

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WAGE SCALE AND CONTRACT RATES

The following wage rates were in effect at the Little Pittsburg mine in October 1946:

	Per shift
	$
Miners)	
Nipper)	
Hoistmen)	
Motormen)	10.23
Timbermen)	
Mill operators)	
Cager)	
Shaftsmen	10.73
Yardmen, sawmill operators	10.23
Compressor men	9.98
Blacksmith	10.73
Mechanic	10.73
Mill helpers	9.73
Bull gang-yard laborer	9.73

The rates in effect from June to December 1945, the period covered in this report, were each $1.48 per shift less than present rates. The difference in rates amounts to a pay increase of 10 percent on gross pay rolls. It will be noticed that most of the men underground receive the same rate, regardless of their duties. This permits flexibility in utilizing the men's services.

Time and one-half is paid for all time over 40 hours per week. A 6-day vacation with pay is provided each year to each man having 270 qualifying shifts.

Contract bonuses are paid at an adjusted hourly rate to all men involved in the contract. Time and a half is also paid on the adjusted hourly contract rate. The contracts are so simple that the miners can tell, within close limits, what they are making. Labor relations at the Little Pittsburg mine are particularly good. The mine has had an ample labor supply throughout the war. The good labor relations are based on fair treatment of the men, good working conditions, good equipment, and good wages.

POWER SUPPLY

The power for the mine and mill is obtained from the Washington Water Power Co. of Spokane, Wash., at a rate of $0.00625 per kw.-hr. An alternate line owned by the Montana Power Co. may be used in emergencies, thus minimizing power interruptions. The power is transmitted to the company's substation at 13,000 volts. A 2,300-volt line is brought into the mine and transformed to lower voltages as required.

The power costs each month are distributed on an arbitrary percentage basis to the mine and mill. The mine assumes 25 percent of the cost and the mill 75 percent.

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POWER REQUIREMENTS

Connected power:

	Horsepower	Horsepower
Mine:		
Compressor, Sullivan, two-stage, class W J, size 18 x 11 x 44 (G.E. induction motor)	150	
Compressor, Gardner-Denver, Model WBH-4011, size 7-1/2 x 5-3/4 x 5, capacity 440 cu. ft. (G. E. Form K. motor)	75	
Compressor, Sullivan, two-stage, class WH-6, size 14 x 8-1/2 x 10 (G. E. motor, Form M, 720 r.p.m.)	100	
Hoist, Western Electric motor	52	
Battery charger, Chandeysson motor-generator set	6.5	
Battery charger, Westinghouse motor-generator set	7.5	
Pump, Ingersoll-Rand, Model A, type 1.5 MRV 25, G. E. type K induction motor, 3,540 r.p.m.	25	
Shaft pump	10	
Blower fan - T.M. 6 Ventair	5	
Miscellaneous, lights, etc.	10	
Total mine		431
Outside:		
Saw motor, G. E. type K. T., 1,740 r.p.m.	10	
Electric tugger, Sullivan double-drum, 1-ton capacity.	7.5	
Total outside		17.5
Mill:		
Coarse screen vibrator and conveyor motor	10	
9 x 15 jaw crusher	50	
Fahrenwald cone crusher	35	
Conveyor belts, coarse grinding	15	
Feeder and belt motor	10	
Ball mill	150	
Classifier, Dorr	7.5	
Exhaust fan	10	
Lead flotation motors, two 10-horsepower motors	20	
Conditioner	5	
Zinc flotation, ten 5-horsepower motors	50	
Filters and bucket elevator	35	
Sand pump	3	
Miscellaneous	5	
Total mill		400.5
Total connected		849.0

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COST OF GENERAL MINING SUPPLIES

During the period covered in this report, the costs of principal mining supplies were as follows:

Mine:

Explosives, 45-percent-strength dynamite	$13.50 to $14.50 per 100 lb.
Fuse	8.70 per 1,000 ft.
No. 6 blasting caps	15.60 per 1,000
Electric delays	14.25 to $16.90 per 100
Drill steel (Q.O.)	17.90 per 100 lb.
Bits cost, new	0.308 each
Bits, reconditioned	.0925 each
Wire rope, 3/4"	.095 per ft.
Track ties	34.00 per 1,000 bd. ft.
Lagging (sawed)	34.00 per 1,000 bd. ft.
Shaft timbers	35.00 per 1,000 bd. ft.
6" stull	0.08 per lin. ft.
8" stull	.10 per lin. ft.
10" stull	.15 per lin. ft.
12" stull	.19 per lin. ft.

Mill:

Cast-iron ball-mill balls, 3" diameter	$65.00 per ton
Ball mill liners	132.00 per ton
Lime	20.50 per ton
Copper sulfate	7.00 per 100 lb.
Soda ash	3.25 per 100 lb.
Zinc sulfate	7.45 per 100 lb.
Cyanide	8.25 per 100 lb.

TABLE 2. - Summary of costs

Little Pittsburg mine - June - December 1945
Tons of ore produced - 23,298
Mining method - square-set stopes in a narrow vein

Underground costs per ton of ore milled

	Labor	Super-vision	Compressed air, Drills, Steel, & Power	Explo-sives	Timber	Other (1) supplies	Total
Development	$0.6635	$0.0191	$0.0778	$0.0890	$0.0586	$0.1353	$1.0433
Stoping	2.4401	.0701	.2860	.2943	.2154	.4976	3.8035
Transportation	.5567	.0160	-	-	-	-	.5727
Total	3.6603	.1052	.3638	.3833	.2740	.6329	5.4195

(1) May include minor items of equipment purchased during period.

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Milling costs per ton of ore milled

	Percent of total milling cost	Total cost per ton
Labor	41.78	$0.7806
Power	16.09	.3007
Supplies	42.13	.7873
Total	100.00	1.8686

General expenses per ton

	Percent of total general expense cost	Total cost per ton
Supervision: Office & labor	50.57	$1.2004
Supplies	8.20	.1947
Hauling concentrates & supplies	8.21	.1950
Taxes	12.87	.3056
Transportation of men to and from mine	4.43	.1052
Miscellaneous (1)	15.72	.3731
Total	100.00	2.3740

(1) Includes employers hospital fees, social security, compensation, bulldozing, road repairs, assaying, accounting and legal expenses, traveling expenses, equipment rentals, etc.

Total mining, milling, and general costs

	Per ton	
Mining:		
Development	$1.0433	
Stoping	3.8035	
Transportation underground	.5727	
Total		$5.4195
Milling:		1.8686
General (office, taxes, freight, etc.):		2.3740
Mining, milling, and general total		9.6621

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TABLE 3. - Summary of mining costs in units of labor, power, and supplies

Little Pittsburg mine - June to December 1945
Tons of ore produced - 23,298
Mining method - square-set stopes in a narrow vein

	Development	Mining	Total
A. Labor (man-hours per ton)	0.450	-	0.450
Breaking (Drilling and blasting)	-	0.454	.454
Timbering	-	.542	.542
Shoveling	-	.021	.021
Subtotal	.450	1.017	1.467
Tramming			
A. Hand	-	.075	.075
B. Motor haulage	.022	.240	.262
Subtotal	.022	.315	.337
Supervision	-	.062	.062
General	.025	-	.025
Nipping	-	.052	.052
Hoisting supplies to stopes	-	.007	.007
Compressor men	-	.155	.155
Shop labor	-	.049	.049
Timber framing labor	-	.059	.059
Repair	-	.112	.112
Subtotal	.025	0.434	0.459
Total labor	.497	1.828	2.325
Average tons per man-shift, including surface labor chargeable to underground operations	-	-	3.440
B. Power and supplies			
Explosives (lb. per ton) 45-percent gelatin and ammonia gelatin	.584	1.929	2.513
Timber (ft. per ton)			
Stulls (bd. ft.)	-	-	2.538
Sawed timber (bd. ft.)	-	-	6.251
Total bd. ft. per ton ore			8.789
Power (kw.-hr. per ton)	-	-	16.036
C. Percent of total cost			
Labor	14.85	54.63	69.48
Supplies	6.13	22.54	28.67
Power	.40	1.45	1.85
Total	21.38	78.62	100.00

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Milling cost in units of labor, power, and supplies

Labor, man-hours per ton milled:	
Supervision	0.072
Crushing	.130
Operating	.303
Repair	.078
Total	.583
Power, kw.-hr. per ton milled:	48.11
Steel, pounds per ton milled:	
Balls	4.077
Liners	.389
Total	4.466
Reagents, approximate pounds per ton milled:	
Copper sulfate	1.70
Soda ash	1.20
Zinc sulfate	1.20
Z_3 Xanthate	.01
Cyanide	.15
B_{23} frother	.01
Minerac	.001

TABLE 4. - Costs of development

Cost of crosscutting per foot[1/]

Labor (breaking, mucking and tramming)	$ 6.4615
Explosives	2.5287
Power (prorated)	.2057
Supplies (est.): Track, ties, steel, airlines, etc.	1.6620
Miscellaneous	.5621
Total cost per foot	$11.4200

1/ No timbering.

Cost of sinking per foot[2/]

Supervision	$ 1.73
Labor	60.27
Explosives	6.38
Power and air (prorated)	7.06
Timber	4.45
Other supplies (estimated)	12.29
Miscellaneous (Insurance, compensation, etc.)	5.24
Total cost per foot	$97.42

2/ Based on cost of sinking 164 feet. Does not include cost of equipment.

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METALLURGICAL DATA FOR 7-MONTH PERIOD

(June to December 1945, inclusive)

	Percent Pb/ton	Percent Zn/ton	Ounces Ag/ton
Head assay	3.014	7.024	1.34
Tail assay	.32	.66	.12
Lead concentrate	63.09	13.87	1/47.844
Zinc concentrate	9.06	50.11	-
Percent recovery	90.7	92.0	92.5
Ratio of concentration	38.6	8.2	-

1/ All silver is assumed to be recovered in lead concentrate. Actual distribution of silver in lead and zinc concentrate is not available.

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